PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H05K 3/00 — A1

(11) International Publication Number: WO 96/18284

(43) International Publication Date: 13 June 1996 (13.06.96)

(21) International Application Number: PCT/US95/15708

(22) International Filing Date: 4 December 1995 (04.12.95)

(30) Priority Data:
08/349,254 5 December 1994 (05.12.94) US

(71) Applicant: TELEDYNE INDUSTRIES, INC. [US/US]; 1901 Avenue of the Stars, Los Angeles, CA 90067 (US).

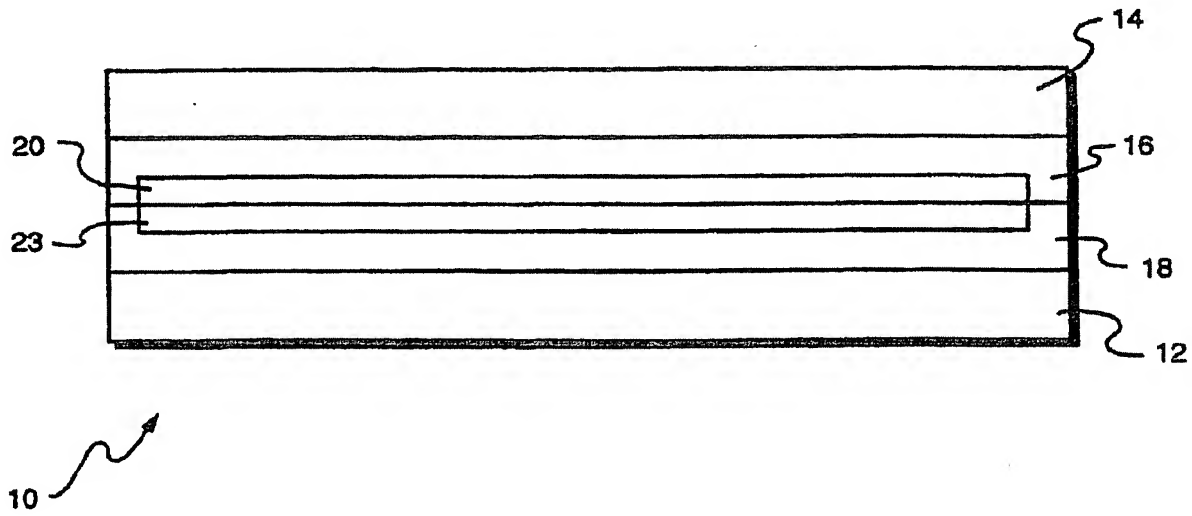
(72) Inventors: CARON, A., Roland; 5 Rose Drive, Hudson, NH 03051 (US). MILLETTE, Lee, J.; 43 Hillcrest Road, Litchfield, NH 03052 (US). KING, John, G.; 409 Forest Street, N. Andover, MA 01845 (US).

(74) Agent: SOLOWAY, Norman, P.; Hayes, Soloway, Hennessey, Grossman & Hage, 175 Canal Street, Manchester, NH 03101 (US).

(81) Designated States: CA, JP, KR, SG, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FABRICATION MULTILAYER COMBINED RIGID/FLEX PRINTED CIRCUIT BOARD



(57) Abstract

Multilayer rigid flex printed circuits are fabricated from a novel basestock composite (10) comprising two copper conducting sheets (12, 14), bonded to insulator layers (16, 18) comprised of fiberglass sheets impregnated with an adhesive such as epoxy, wherein the insulator layers are both affixed to Kapton layers (20, 23) wherein said Kapton layers are not coextensive with the borders (24) of the insulator layers. The basestock composite (10) can then be imaged and etched on the conductor layers (16, 18) to form conductor patterns (22), laminated or coated with a coverlay (30) of dielectric material, and the basestock can be cut at a point internal to its borders (24) and into the Kapton layers thereby separating two imaged and etched conductor layers.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

FABRICATION MULTILAYER COMBINED RIGID/FLEX PRINTED CIRCUIT BOARD

The present invention relates to the fabrication of multilayer combined rigid and flex printed circuits having flexible printed circuits extending from the rigid board. In particular, the present invention relates to an improved process for the fabrication of multilayer combined rigid and flex printed circuits, wherein two circuit boards having rigid and flexible sections can be prepared from a novel basestock composite.

Techniques for making multilayer rigid flex printed circuit boards are well known in the art. One early example of the prior art is disclosed in U.S. Patent No. 3,409,732, assigned to the Assignee of the present application and whose teachings are incorporated by reference. Another example is disclosed in the parent of instant application, Serial No. PCT/US9311684, which is also assigned to the assignee of this application and whose teachings are incorporated herein by reference. Typically a rigid flex stacked printed circuit board includes flexible printed circuit cables extending from the periphery of the rigid section or sections. The rigid portions of the flex cables are typically used as sites for electronic components or mechanical hardware. It is important to note that the copper conductor in each plane or layer is fabricated from one continuous sheet of copper foil.

With improvements in electronic technology, there has been a constant need for advances in electronic packaging. This need has led to more complex multilayer rigid flex printed circuit boards with many boards now using up to twenty-five, or even more, layers of circuitry. However, severe problems developed when the rigid circuit portions included many layers of conductors and holes plated through with copper to provide conductor barrels connecting the conductor layers.

One particular problem, reported on and discussed in U.S. Patent No. 4,800,461, assigned to the assignee of the present Application, and whose teachings are incorporated by reference, described the fact that in multilayer rigid flex boards which include insulator materials such as acrylic adhesive and Kapton (Kapton is a trademark of E.I. duPont de Nemours and Company Inc. for polyimide film), the insulating materials placed a "Z-axis" stress on plated through holes. The coefficient of thermal expansion, it was reported, of the acrylic adhesive (Z-axis expansion) was the dominate influence. It was observed that because of the amount of acrylic required in many multilayer rigid flex applications, all plated through holes are stressed, with many cracking, making the boards unusable.

To overcome this problem, the '461 patent reported on a novel process to provide a rigid section incorporating insulator materials which, when subjected to elevated temperatures, did not expand in the Z direction to cause difficulties, including delamination and cracking of plated copper barrels. Stated another way, in the '461 patent, the materials causing undesirable expansion in the Z direction in the multilayer rigid section of the board, and the materials absorbing excessive amounts of moisture, such as acrylic adhesives and Kapton, were eliminated from the boards rigid section.

However, although the '461 patent was extremely successful in addressing the various problems recited therein, and in particular, the problem of thermal stresses described above, the process for fabrication of the rigid flex printed circuits has remained limited to the fabrication of a multilayer combined rigid and flex printed circuit board wherein two circuit boards are always prepared from a basestock composition, and remain attached to one another via the prepreg. In other words, the process of fabrication according to the teachings of

the prior art begin with the step of laminating two conductor layers (i.e. copper layers) to a single insulator layer (prepreg) followed by imaging and etching. Accordingly if one of the two bonded conductor layers was somehow improperly imaged, it was necessary to discard the entire lamination.

Other problems also persist. One problem concerns the inability to satisfactorily mount die and interconnection lines to flexible substrate sections. Substrates currently in use distort and/or frequently delaminate when subjected to thermosonic bond techniques used to bond die, and during formation of fine line interconnection lines in the substrate. These conditions can yield unsatisfactory results in applications where high levels of design integration and uniformity among similar features on the substrate are required.

It is therefore an object of this invention to provide a novel basestock composition of sufficient planarity and rigidity to permit adequate handling and further processing thereof, and which can be separated into two individual layers each comprising an imaged copper layer laminated to a fiberglass sheet which is impregnated with adhesives such as an epoxy, which has been laminated and bonded to acrylic coated polyimide film.

It is yet another object of this invention to provide a multilayer combined rigid and flex printed circuit substrate that provides sufficient rigidity to permit satisfactory mounting of die using thermosonic bonding techniques and formation of fine line interconnections.

The present invention provides a multilayer rigid flex printed circuit board fabricated by a novel process and from a novel basestock composite wherein two copper sheets are laminated to a prepreg and in-between said laminated copper sheets is placed at least two layers of polyimide material carrying an acrylic adhesive that is not coextensive with the borders of the prepreg, such that the

basestock can be imaged and processed in the usual manner, and laminated or coated with a coverlay of dielectric material, and such that cutting the edges of the basestock material, after imaging, at a location internal to the basestock border provides a cut into the polyimide layer, thereby allowing for separation of the two individual imaged copper layers and their supporting prepreg.

In a further embodiment, the present invention provides a printed circuit basestock composite wherein two conductor sheets are laminated to a polyimide insulating layer carrying an acrylic adhesive, and in between said laminated conducting sheets is placed a release layer that is not coextensive with the borders of the polyimide insulating layer, and wherein the release layer is further separated by a carrier layer which is coextensive with laminate borders, characterized in that the carrier layer provides rigidity to the laminate. This laminate can therefore be imaged and processing in the usual manner, and cutting the edges of this basestock material, after imaging, at a location internal to the basestock border provides a cut into the release layer, allowing for separation of the two individual imaged copper layers, with removal of the carrier layer.

The foregoing and other features and advantages of the present invention will be more readily understood and will become apparent from the following detailed description taken in conjunction with the drawings, in which:

Fig. 1 is an exploded view of the novel basestock composite.

Fig. 2 is an exploded view of the novel basestock composite showing it cut at a point internal to its borders and into the Kapton layers.

Fig. 3 is an exploded view of the novel basestock composite with a prepreg and Kapton/acrylic covercoat.

Fig. 4 is an exploded view of the novel basestock composite, wherein a carrier layer is placed within the

release layer of the laminate.

In the first exemplary embodiment of the invention shown in Fig. 1, the novel basestock composite 10 is shown to comprise two copper conducting sheets 12 and 14, for example, one or two ounce copper, bonded to insulator layers 16 and 18 comprised of fiberglass sheets impregnated with an adhesive such as epoxy, and commonly referred to as a prepreg. Also shown in Figure 1 are the two layers of Kapton material 20,23 which are shown as not being coextensive with the borders of the insulating layers 16 and 18.

Accordingly, it can be appreciated that in the method of preparation of the novel basestock composite 10, a pair of conducting sheets or layers, 12 and 14, are laminated to the opposite surfaces of insulating layers 16 and 18, wherein the insulating layers are both affixed to Kapton layers 20,23 and wherein said Kapton layers are not coextensive with the borders of the insulating layers. It can be appreciated that the basestock composite comprising the pair of conducting sheets has sufficient planarity and rigidity to permit handling and further processing thereof, and in particular, imaging to form conductor patterns.

Turning then to Fig. 2(not drawn to scale with regards to the thickness of the individual layers), the basestock composite which has been imaged and etched to form conductor patterns 22, is cut at a point internal to its borders 24 and into and through the Kapton layers 20,23 and the two conductor layer patterns 26 and 28 are separated. Each conductor layer can then be further processed, as described below. (It is to be noted however, and as specifically shown in Fig. 2, this particular configuration lends itself to cover-coating 29 prior to separation.)

Figure 3 shows one of the separated conductive layers 14 and its adjacent prepreg 18 further covered with

another flexible insulating layer of a Kapton/acrylic covercoat 30. Alternatively, the Kapton/acrylic covercoat 30 can be replaced with a less expensive photoimagable solder mask.

Figure 4 shows an exploded view of the novel basestock composite wherein a carrier layer is placed within the release layer of the laminate. That is, with reference to Figure 4, conducting layers 34 are affixed to Kapton layers 36 carrying an acrylic adhesive. At 38 there is placed a release layer that is not coextensive with the borders of the polyimide insulating layer, and wherein the release layer is further separated by a carrier layer 40 which is coextensive with the laminate borders, characterized in that the carrier layer provides rigidity to the laminate. Preferably, the polyimide layers comprise Kapton, and the carrier layer is fiberglass, and the release layer is poly(vinyl fluoride) film, or Tedlar.

It can be appreciated that the basestock composite shown in Figure 4, can be imaged and etched to form conductor patterns, followed by cutting the basestock composite at a point internal to the borders of the composites and into the release layer. At this point the two imaged and etched conductor layers can be separated and the carrier layer can be removed. Accordingly, by incorporating the carrier layer in such a fashion, the two conductor sheets can be imaged and etched, and the carrier layer provides sufficient flexural strength to the composite for the required imaging and etching operation. Furthermore, it will be appreciated that the construction shown in Fig. 4 can also be cover-coated prior to separation.

While the invention has been shown and described with reference to the above described embodiments, which provide rigid flex circuits affording advantages not found in prior art printed circuits, it will be understood that various changes may be made without departing from the spirit and scope of the invention as defined in the appended claims.

CLAIMS

1. A process for the fabrication of two flexible printed circuit boards comprising the steps of

laminating a pair of conductor layers to respective opposite surface of an insulating layer wherein the insulator layers are each affixed to a poly(imide) layer and wherein said polyimide layers are not coextensive with the borders of the insulating layers, thereby forming a basestock composite;

imaging and etching said conductor layers to form conductor patterns;

laminating or coating a coverlay of dielectric material;

cutting the basestock composite at a point internal to the borders of said composite and into the polyimide layers;

separating the two imaged and etched conductor layers.

2. A process according to claim 1, including the step of covering the conducting layer on one side with a photoimagable solder mask.

3. A process as defined in claim 1, wherein the insulating layers are fiberglass layers, and including the step of impregnating the fiberglass layers with an epoxy adhesive.

4. A printed circuit basestock composite which allows for the preparation of two flexible circuit boards that can be separated, after imaging, comprising

a pair of conductor layers 12, 14 laminated to respective opposite surfaces of an insulating layer 16, 18 wherein the insulator layers are both affixed to respective polyimide layers 20, 23 and wherein said polyimide layers are not coextensive with the borders of the insulating layers, thereby forming a basestock composite 10;

imaging and etching said conductor layers 12, 14 to form conductor patterns;

cutting the basestock composite 10 at a point internal to the boarders of said composite and into the polyimide layers;

separating the two imaged and etched conductor layers.

5. The rigid flex basestock composite of claim 4 wherein the polyimide layers 20, 23 are Kapton, and the insulating layers 16, 18 are fiberglass layers impregnated with an epoxy adhesive.

6. A printed circuit basestock composite which allows for the preparation of two flexible circuit boards, that can be separated, after imaging, and etching comprising

two conducting sheets 34 laminated to a polyimide insulating layer 36 carrying an acrylic adhesive, and in-between 38 said conductive sheets is placed a release layer that is not coextensive with the borders of the polyimide insulating layer, and wherein the release layer is separated by a carrier layer 40 which is coextensive with basestock composite borders, characterized in that the carrier layer provides rigidity to the basestock.

7. The basestock composite of claim 6 wherein the polyimide layer 36 is Kapton, the release layer is poly(vinyl fluoride), and the carrier layer 40 is fiberglass.

8. A process for the preparation of two flexible printed circuit boards comprising the steps of

laminating a pair of conductor layers to respective opposite surfaces of a polyimide layer carrying an acrylic adhesive wherein the polyimide layers are each affixed to a release layer that is not coextensive with the borders of the polyimide insulating layers;

placing within the release layer a carrier layer characterized in that the carrier layer is coextensive

with the borders of the basestock and provides rigidity to the basestock;

imaging and etching the conductor layers to form conductor patterns;

cutting the basestock composite at a point internal to the borders of the composite and into the release layer; and

separating the two imaged and etched conductor layers and the carrier layer.

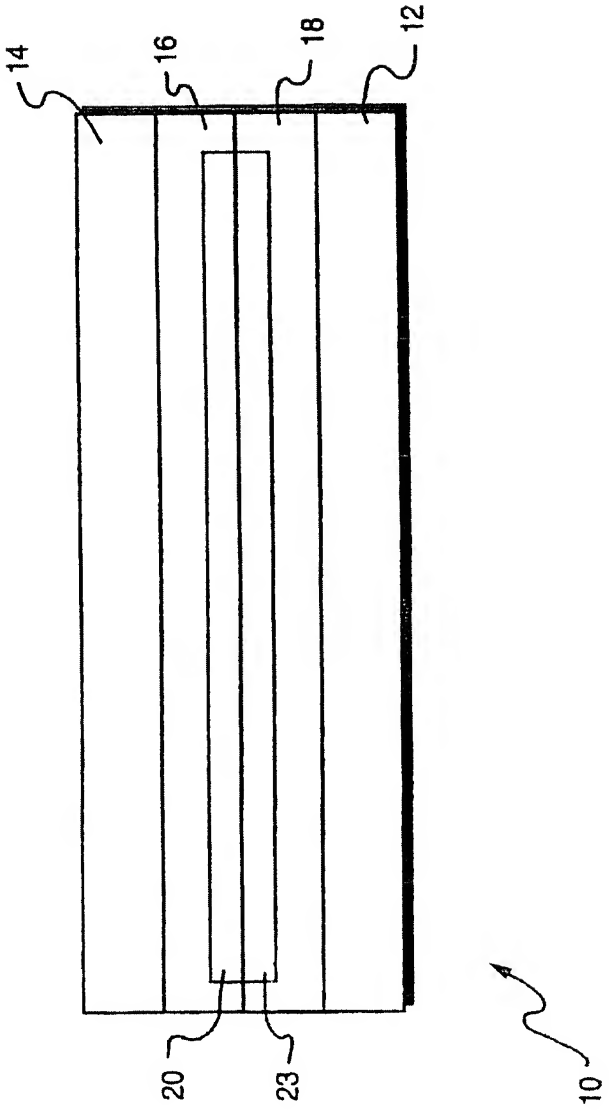


FIG. 1

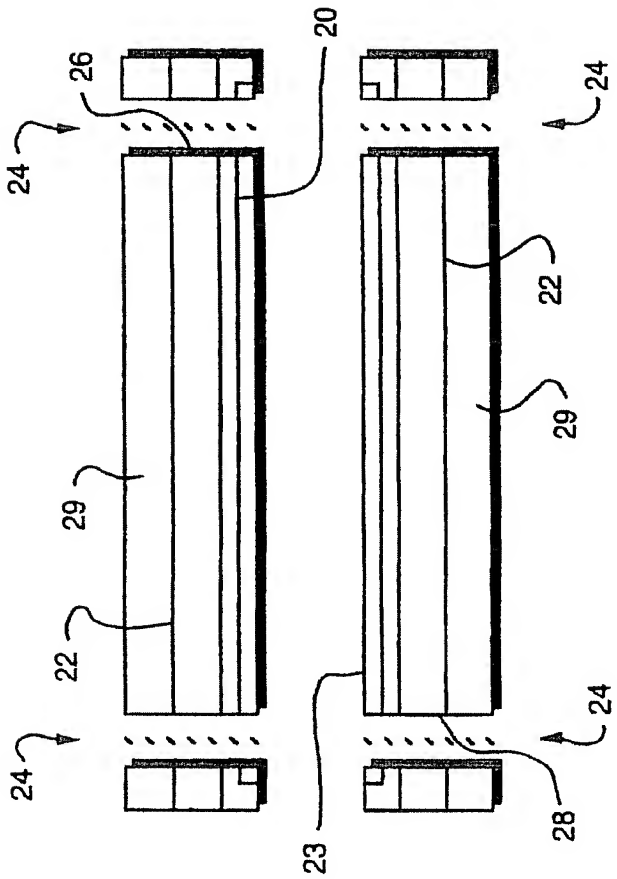


FIG. 2

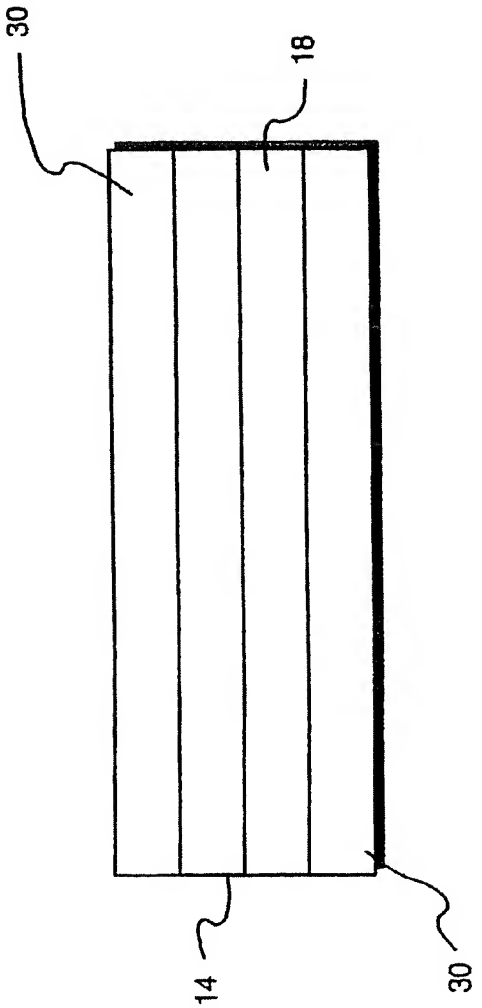


FIG. 3

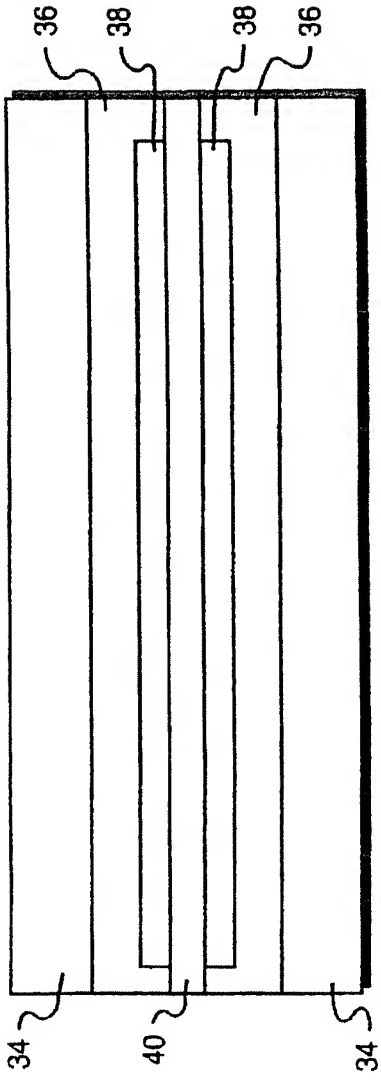


FIG. 4

INTERNATIONAL SEARCH REPORT

Inter ual Application No
PCT/US 95/15708

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05K3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 470 740 (TELEDYNE INDUSTRIES) 12 February 1992 see the whole document	1-5,7
X	---	6,8
Y	EP,A,0 440 928 (FIRMA CARL FREUDENBERG) 14 August 1991 see column 3, line 47 - column 4, line 11; figures 6,7	1,3-5

A	US,A,5 144 742 (LUCAS ET AL.) 8 September 1992 see column 4, line 67 - column 5, line 38	1,3-6
Y	---	2
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
13 March 1996	21. 03. 96
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Mes, L

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter ial Application No
PCT/US 95/15708

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DATABASE WPI Week 8743 Derwent Publications Ltd., London, GB; AN 87-304117 & JP,A,62 214 939 (MATSUSHITA ELEC WORKS) , 21 September 1987 see abstract	7
A	GB,A,2 249 219 (NIPPON CMK CORP.) 29 April 1992 see the whole document	1,2,4,6,8
A	EP,A,0 348 632 (INTERNATIONAL BUSINESS MACHINES CORP.) 3 January 1990 see column 6, line 2 - line 22; figures	1,4
A	DATABASE WPI Week 7947 Derwent Publications Ltd., London, GB; AN 79-85343b & JP,B,54 034 142 (SHIN KOBE ELECTRIC MACH CO) , 25 October 1979 see abstract	1,4,6,8
A	PATENT ABSTRACTS OF JAPAN vol. 14 no. 528 (E-1004) ,20 November 1990 & JP,A,02 224294 (SHIN KOBE ELECTRIC MACH CO) 6 September 1990, see abstract	1,4,6,8
A	PATENT ABSTRACTS OF JAPAN vol. 16 no. 62 (M-1211) ,17 February 1992 & JP,A,03 256740 (SHIN KOBE ELECTRIC MACH CO) 15 November 1991, see abstract	6
A	US,A,4 800 461 (DIXON ET AL.) 24 January 1989 cited in the application see column 5, line 8 - line 37; figure 5	1,3-6

1

INTERNATIONAL SEARCH REPORT

information on patent family members

Inter ial Application No
PCT/US 95/15708

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-470740	12-02-92	US-A-	5095628	17-03-92
		AT-T-	117160	15-01-95
		DE-D-	69106624	23-02-95
		DE-T-	69106624	10-08-95
		ES-T-	2066360	01-03-95
		JP-A-	6342980	13-12-94
		US-A-	5175047	29-12-92
EP-A-440928	14-08-91	DE-C-	4003344	13-06-91
		JP-A-	4213888	04-08-92
		US-A-	5144534	01-09-92
US-A-5144742	08-09-92	NONE		
GB-A-2249219	29-04-92	JP-A-	4154188	27-05-92
EP-A-348632	03-01-90	US-A-	4918812	24-04-90
		JP-A-	2033998	05-02-90
US-A-4800461	24-01-89	NONE		